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FORWORD

This research workshop is intended to promote discussion and the free exchange of ideas in an area of considerable interest to the fields of fracture and fatigue; namely the characterisation of crack tip fields and, in particular, to consider the issue of more accurate multiparameter characterisation, often using a number of simultane-ous sophisticated experimental techniques to validate analytical advances. Invited participants will be expected to prepare a 20 minute presentation on a topic of close relevance to the workshop theme, and significant time will be devoted to discussing the ideas presented to identify fruitful avenues for future work and collaboration.

The organisers want to express their severe gratitude to

ZF Friedrichshafen AG

for financial support.

M. Vormwald

CONTENTS

CONTENTS

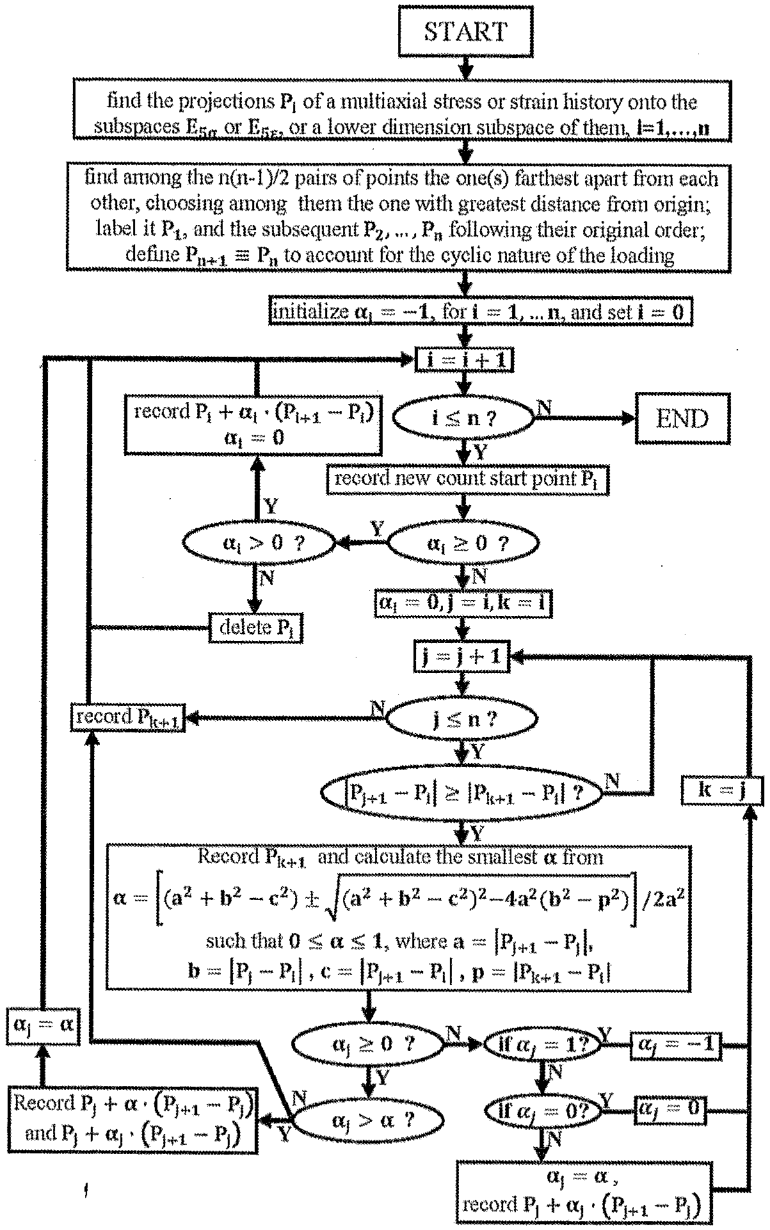

Fig. 1 Flowchart of the proposed rainflow counting algorithm

On the use of the elasto-plastic Point Method to design notched metals against multiaxial fatigue loading

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ABSTRACT

This paper deals with the formulation and experimental validation of a novel fatigue lifetime estimation technique suitable for assessing the extent of damage in notched metallic materials subjected to in-service proportional/non-proportional constant/variable amplitude multiaxial load histories.The methodology being formulated makes use of the Modified Manson-Coffin Curve Method, the Shear Strain-Maximum Variance Method and the elasto-plastic Theory of Critical Distance, with the latter theory being applied in the form of the Point Method. The accuracy and reliability of our novel fatigue lifetime results we generated by testing, under proportional/non-proportional constant/variable amplitude axial-torsional loading, V-notched cylindrical specimens made of unalloyed medium-carbon steel En8 (080M40). Specific experimental trials were run to investigate also the effect of non-zero mean stresses as well as of different frequencies between the axial and torsional stress/strain components.This systematic validation exercise allowed us to demonstrate that our novel multiaxial fatigue assessment methodology is remarkably accurate, with the estimates falling within an error factor of 2. By modelling the cyclic elasto-plastic behaviour of metals explicitly, the design methodology being formulated and validated in the present paper offers a complete solution to the problem of estimating multiaxial fatigue lifetime of notched metallic materials, with this holding true independently of sharpness of the stress/strain raiser and complexity of the load history.

The proposed algorithms are validated by means of a database with experiments from literature. Results show the effectiveness of the developed approaches for ductile materials. The modified local strain concept is a significant improvement. Best results are attained by using the simplified multiaxial notch approximation in combination with the extended short crack model. With prior knowledge of a component S-N curve, highly accurate predictions for complex loading conditions are feasible, when using a modified stress concept, too.

Comparative study on the accuracy of different concepts for the evaluation of the fatigue strength of structures under locally multi-axial loading

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ABSTRACT

The paper presents a case study containing experimental and theoretical investigations on antiroll bars for heavy duty truck axles subject to multiaxial-proportional stresses. The antiroll bars under investigation are made of high-strength steels subject to cold forming and shot peening.

Material investigations were executed to quantify significant fatigue life influencing surface properties like residual stresses and roughness resulting from the manufacturing process.

Fatigue tests under fully reversed loading (force ratio R=-1) at various load amplitudes were executed to determine the stabilizers' S-N curves covering the complete range of interest, from the Low Cycle Fatigue area until the "technical" endurance limit. Additional tests under variable amplitude loading (testing spectra) were also executed to investigate operational load sequence effects on fatigue life.

Finite element analysis and, thereafter, analytical fatigue life calculations using multiaxial hypotheses and damage parameters (Gough-ellipses, P_J-parameter) have been executed to investigate their calculation accuracy and, therewith, their capability for theoretical analysis of such engineering components.

Strain gages measurements performed during the tests validate the finite element simulations. Comparison of experimentally and theoretically determined stresses and fatigue lives is satisfactorily and pinpoints the great potential of the theoretical procedures for such industrial applications.